

VIII. CONCLUSIONS AND RECOMMENDATIONS

White shrimp

The 1983-1990 decline in white shrimp was probably part of a natural, climatically-influenced population cycle, or the result of overharvesting. Recent regulation of the shrimping industry should be monitored to ensure that sufficient protection of the white shrimp resource is in place. The causes of any future decline should be investigated rigorously. The effects of recent regulatory changes cannot be separated from the beneficial effects of high freshwater inflows and mild winters associated with the recent El Niño event. River inflows should not be regulated to the extent that natural variability in inflows (periodic floods) are eliminated, which would probably have the effect of reducing long-term shrimp productivity.

Blue crab

The potential problem represented by declines in blue crab populations has also been recognized by the Texas Parks and Wildlife Department in the formulation of the Texas Blue Crab Fishery Management Plan (Cody et al. 1992). The Plan recommended that certain measures be considered for adoption as Department regulations: that crab trap tending be confined to daylight hours, that rules pertaining to the spacing and marking of crab traps (now in effect locally) be extended coastwide, that the seizure of abandoned crab traps be authorized, and that escape vents be used on all traps to reduce bycatch. In addition, the Plan recommended present monitoring efforts be maintained and expanded and data collected to assess the current allocation of the blue crab resource among user groups.

Government and private organizations at all levels can contribute towards the reduction in wasteful crabbing practices. The recent establishment of a trap identification system (trap tagging and floats) will provide more precise effort data and reduce the number of stolen, lost, and abandoned crab traps (Cody et al. 1992). However, law enforcement will have to be intensified if illegal crabbing is widespread. Efforts to remove debris from coastal areas should place an emphasis on recovering abandoned crab traps. The use of biodegradable panels on traps should be promoted to reduce ghost fishing. Above all, the public should be educated that blue crab are not an unlimited resource.

Birds

The declining trends among wading birds that feed at the marsh-bay interface may be an early warning of a potentially serious problem with tidal wetlands, whether the ultimate cause lies in tidal marsh acreage, pollution, small fish populations, or disease. Bird morbidity and contamination of bay margin habitats should be specifically investigated. A background study on rates of parasitization and contaminant body burden in birds (especially black skimmers) throughout the estuary would be relatively inexpensive to perform.

Birds are valuable indicator species because they have relatively slow population turnover, require more extensive high-quality habitat than do most fisheries species, and are sensitive to many contaminants. Most species are not hunted by man, and therefore are not affected by one major source of interannual variation. As birds are important to the health of the bay, the bay is important to the health of birds; the Galveston Estuary is nationally important to the survival of the piping plover.

The following species have been recommended for monitoring (Eubanks, Ortego, pers. comm.):

- 1) The American oyster catcher and the seaside sparrow are non-migratory, obligate estuarine species. A decline in these species indicates a decline in estuarine health. The oyster catcher inhabits oyster reefs and mud flats and is not common, but is easy to recognize. The seaside sparrow, found on the edges of Spartina alterniflora marsh, is fairly common, though difficult to survey because of its small size and cryptic coloration.
- 2) Certain obligate marsh-dwelling birds should be monitored as indicators of the state of marsh communities: the clapper rail, associated with Spartina alterniflora; the black rail, an obligate associate of Spartina spartinae (but possibly hard to monitor because of its obscure coloration); and the marsh wren, associated with Phragmites and other tall emergent grasses.
- 3) Wilson's plover and least terns should be monitored as indicators of beach environments. Both breed on Galveston Island and are affected by development in the area.
- 4) Less appropriate indicator species are those that move frequently between inland and coastal areas, such as the little blue heron, or are exclusively coastal but highly migratory, such as the reddish egret.
- 5) Shorebirds should be monitored because so little is known about the status of their populations. Programs associated with the Salt Bayou Project are now being designed to count and identify birds along transects flown by helicopter (B. Ortego, pers. comm.). This method is relatively economical, but will be biased towards those birds that are large and easy to identify.

Other factors

There are aspects of the seafood harvest that are not documented by existing means of collecting data. This is especially true of those fishermen that do not use boat ramps or keep licensed boats, including a large portion of the recreational and subsistence fishermen. Landings and effort by the commercial fishery should be documented independently of self-reporting. Overflights, spot checking of fish markets and roadside seafood sellers, and spot interviews of recreational and subsistence fishermen should be continued. The management implications of any data recovered this way should also be addressed.

The causes and implications of the trends in water quality parameters reported by Ward and Armstrong (1992), declines in turbidity, nitrates, and chlorophyll *a*, should be investigated thoroughly. Declining primary productivity may be associated with a positive reduction in nutrient loading from wastewater or runoff, but may also indicate wetland loss is affecting the ecosystem as a whole. The consequences of not understanding the causes of these trends and their effects on the estuarine ecosystem are potentially severe, both ecologically and economically.

The reduction of variation in freshwater inflows involves more than the alteration of the salinity regime. The role of freshwater inflows in nutrient cycling is one of the most important estuarine processes. The effects of seasonal and interannual variation in inflows should be investigated in the context of a thorough study of climate effects on the Galveston Bay biota and the role of large-scale climatic phenomena. There are many scenarios for future climate change; to be prepared for change, the existing system needs to be as well understood as possible.

An ideal sampling program?

The GBNEP created a committee with the purpose of designing a comprehensive sampling program to monitor changes in the estuarine biota. Ideally, the committee should coordinate existing private and governmental sampling programs (including the CF program) to reduce duplication of effort and to address gaps in information. A monitoring program will be needed well beyond the duration of the Galveston Bay National Estuary Program (to be completed in fall 1994), and should also involve rigorous analysis of the data collected, with the goal of assuring the health of the Galveston Estuary.

Such a program should track short-lived organisms (phyto- or zooplankton) as measures of ambient estuarine quality, and longer-lived organisms (larger shellfish, fishes, and birds) as measures of trends in estuarine quality. In addition to the birds listed above, certain aquatic organisms should be specifically monitored: oysters and spotted seatrout, because they spend all or most of their lives in a single estuary; and abundant species such as shrimp, menhaden, and blue crab, because of their economic importance and role in the food web. These and the organisms discussed in Loeffler and Walton (1992) are among the most conspicuous and best-documented members of the estuarine biota. Other organisms are undoubtedly important to the estuarine ecosystem but have received little attention, such as ctenophores, cnidarians such as cabbage heads, insects, and bay benthos in general. Organisms should be routinely counted, measured, and checked for anomalies. Habitat parameters should be routinely recorded (water quality measurements, sediment composition and friability, vegetation type). Samples should be spot-checked for contaminants and nutrient levels in a manner that can be directly related to the sampling of fish and birds. Monitoring should specifically address nutrient cycling and community relationships.

The methodology of the ideal sampling program should be diverse to address a variety of scales. The best monitoring program is one that can account for local habitats and

communities, as well as changes in single species, throughout an estuary. Thanks to remote sensing technology, it is now possible to inventory the vast emergent part of the estuarine drainage and to quantify vegetation types and substrate with less manpower than required by ground surveying. Remote monitoring is reasonably accurate if combined with extensive ground truthing and field work. Plans for this kind of program are being discussed in association with the Salt Bayou Project and should be coordinated with other efforts to monitor the estuary. Though remote sensing cannot be applied in detail to submerged habitats, it is being profitably applied to the mapping of circulation patterns. The estuary should be routinely surveyed by helicopter or plane to monitor fishing and shrimping activity, and to count large organisms such as marine mammals, turtles, and birds.

Data collection should be directed at measuring the health of the estuary and the factors that influence it most strongly. The committee should carefully consider the definition of estuarine health, because this should be integrated with the goals of bay-wide management efforts. An understanding of estuarine health would require the adequate description of the structure and function of all components of the estuarine ecosystem, many of which (discussed above) are unknown.

As part of the bay's yearly physical check-up, the committee should assemble and distribute a yearly (or more frequently, if necessary) report on the state of health of the estuary. Such reports could direct attention to problems as they develop and before they become severe. If any suspicious conditions are found, the reports should pose a tentative diagnosis, recommend further testing, and suggest treatment. The intrinsic interest of the Galveston Estuary and its value to the Texas economy require that its health be taken seriously.